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Valuation of environmental public goods and services at different spatial scales: a review

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To manage environmental problems in an adequate way, it is essential to take different spatial scales into consideration. As a tool for decision making, it would be beneficial if valuation methods take spatial scales into account as well. In this article, we review the valuation literature with regard to the spatial scales of environmental public goods and services to which the contingent valuation method, hedonic pricing method, and travel cost method have been applied in the past. We classified 117 environmental case studies to the local, landscape/watershed, regional, and global scales. These case studies cover a broad range of environmental goods and services, such as green space in a city, air quality, rivers, natural areas, and a stable climate system. Additionally, we took into account the year of publication of the case studies. Our results show that the majority of the environmental case studies are related to the local and landscape/watershed scales. However, the number of case studies on the regional and global scales has been increasing in recent years. This article argues that such a change in spatial scale calls for a debate on scaling issues in the field of environmental valuation.

Keywords: monetary valuation; spatial scale; environmental public goods

Introduction

In the last few decades, the growth in production and consumption has led to an increasing pressure on humanity on the earth. The use of natural resources, like minerals, land, and freshwater, and the emissions of substances to air, water, and soil have led to changes in environmental quality. Fine-particulate air pollution from traffic, for example, has negative effects on human health in cities (Dockery et al. 1993; Beelen 2008). The emissions of sulfur and nitrogen oxides in Western Europe have led to acidification of lakes in Norway and Sweden (see www.unece.org/env/lrtap). It is now widely recognized that CO₂ emissions contribute to global warming, which may eventually result in climate change. These examples illustrate that environmental impacts take place at different spatial scales, that is, the local, regional, and global scales.

Spatial scale usually refers to the physical dimensions in space (Peterson and Parker 1998a). Accordingly, an increase in spatial scale implies an increase in space,

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for example, the adverse health effects of traffic-related air pollution may be experienced most severely near roads and in cities, whereas sulfur emissions can travel several thousands of kilometers before deposition and acidification take place. The potential impact of climate change may even be observed around the globe. However, an increase in spatial scale may also involve a change in the level of organization of a system (see, e.g. Peterson and Parker (1998b)), that is, an increase in the number of processes and the interrelations between the processes that lead to a certain environmental impact. The impact of climate change, for example, depends on multiple processes that are intertwined with each other. To manage environmental problems in an adequate way, it is essential to take different spatial scales into consideration (Peterson and Parker 1998a).

Environmental planning and decision making is a complex process in which objectives are often mutually exclusive and trade-offs are inevitable (Peterson and Parker 1998a). Environmental valuation can facilitate management decisions, as it can express environmental assets just as other factors in the decision-making process in a common denominator, that is money. A variety of techniques have been developed to reveal the preferences of individuals for nonmarket environmental goods. Firmly established preference methods are the following: the contingent valuation method (CVM) (Davis 1963), the hedonic pricing method (HPM) (Rosen 1974), and the travel cost method (TCM) (Clawson and Knetsch 1969).

As a tool for decision making, it would be beneficial if valuation methods take spatial scales into account as well. Several valuation studies investigated the sensitivity of respondents to the physical dimension of the valued item. Brander et al. (2007) showed that reef recreationists are sensitive to the scope of the area they visit. In other words, reef recreationists prefer larger diving sites. Similar results were found in earlier studies regarding the visibility of national parks (Smith and Osborne 1996), the habitat of the giant panda (Kontoleon and Swanson 2003), and health risk reductions (Bateman and Brouwer 2006). A small number of valuation studies explicitly discuss spatial scales. These studies distinguish spatial scales at which ecosystem services are being supplied and demanded by stakeholders (Turner et al. 2000; Hein et al. 2006; Mander et al. 2007; Martín-López et al. 2009). Hein et al. (2006) illustrate this in a case study on the valuation of ecosystem services of a wetland in The Netherlands. From this case study it appears that the monetary valuation of services at the global scale is particularly difficult and that further research is required to quantify the global value of nature and biodiversity. Furthermore, Hein et al. (2006) highlight the need to assess the role of scales of ecosystem services in relation to CVM.

In this article, we aim to review the spatial scales at which conventional valuation methods have been applied in the past. This review may serve as a starting point for a discussion on scaling issues in environmental valuation practices. For our analysis, we selected case studies that used the CVM, HPM, and TCM. Other valuation methods have varying names which hampers a consistent search for case studies. We first explain the procedure for the selection of case studies (the section entitled "Method"). Second, we present the classification of case studies to different spatial scales (the section entitled "Results"). Third, we discuss the application of valuation methods at different spatial scales (the section entitled "Discussion"). Finally, we draw some conclusions in the section entitled "Conclusions".

Method

Selection of studies

When choosing a database for our analysis, we aimed for a database with a large time span, because the valuation of environmental quality has received ample attention in scientific literature for decades. Therefore, we selected Web of Science^{®1} because this database has both a large time span (1945 to present) and a broad coverage of publications in comparison with other databases, such as ScopusTM or ScienceDirect[®].

From Web of Science, we selected a number of studies based on the following criteria:

- Document type: We only included articles and reviews. Studies without abstract were omitted from our study.
- Time span: All years from 1945 to 20 September 2008.
- Keywords: We reviewed the literature regarding studies on the most widely employed methods to nonmarket valuation of environmental changes, including the CVM, HPM, and TCM. To select such studies, we used keywords in the search field “topic”, which includes article titles, abstracts, author keywords and KeyWords Plus.² For the CVM, we used the keyword “contingent valuation”. For the HPM, we used the keyword “hedonic pricing”. For the TCM, we used a combination of two keywords, namely, “travel cost” and “valu*”. The keyword “valu*” retrieves all words that start with “valu”, for example, valuation, valuing, and value. In this way, we avoided studies that used the term “travel cost” in their title, abstract, or keywords, but did not use the TCM.
- Sample: Because of the large number of studies retrieved, we randomly selected 10% of the CVM studies and 25% each of the HPM and TCM studies.

Classification of studies

From our sample of studies, we first collected all original case studies. Case studies were counted when they were mentioned in the title, abstract, or keywords or when the author referred to a case study implicitly. This implies that we counted all applications of valuation methods including independent case studies as well as case studies that illustrate a theory or methodological issues. Previously published case studies that are used in the context of reviews, methodological issues, meta-analyses, benefit transfer, or comments were not considered as original case studies. With this approach, double counting of case studies was avoided as much as possible.

We then selected all case studies related to environmental issues. Case studies can have different subjects, for example environmental quality, health, risk reduction, and agriculture. These subjects can partly overlap. Our analysis considers all case studies that relate to environmental quality or environmental impact. As a result, some studies may concentrate on the value of environmental quality with a point of tangency to health, agriculture, or risk reduction. For example, the quality of drinking water can be related to environmental quality as well as human health.

Finally, we classified the case studies on environmental issues into spatial scales. Often environmental public goods are generated and supplied at a particular scale, although benefits accrue to stakeholders at other scales (Mander et al. 2007; Martín-López et al. 2009). Environmental quality at the landscape scale, for example

wetlands in The Netherlands, can supply services at different spatial scales, including global biodiversity (Hein et al. 2006). On the other hand, environmental quality at the global scale, like a stable climate system, can provide services at the regional scale, for example, control of the future average annual temperature (Cameron 2005). When classifying the case studies into spatial scales, we focused as much as possible on the physical dimension of the valued item, such as the dimensions of a Lake or a National Park, rather than on the spatial scale of the stakeholders who consume the environmental public good. This approach helped us to classify the valued items in an objective and consistent way. We clustered the case studies into the following spatial scales: local ($< 10 \text{ km}^2$), landscape/watershed (10 km^2 – $10,000 \text{ km}^2$), regional ($10,000 \text{ km}^2$ – $1,000,000 \text{ km}^2$), and global ($> 1,000,000 \text{ km}^2$). It is important to realize that the divisions in the spatial scale continuum are arbitrary.

Results

Sample of studies

Table 1 shows the number of studies that we obtained stepwise with our selection procedure in Web of Science. With our search criteria, we obtained 2048 hits for CVM, 131 hits for HPM, and 202 hits for TCM. Apparently, CVM studies are abundant in the valuation literature. There are about 10 times more CVM studies than TCM studies or HPM studies. Subsequently, we selected 10% of the CVM studies and 25% of both the HPM and TCM studies, resulting in a sample size of 289 studies in total. After a close inspection of these 289 studies, it turned out that our sample contained 117 environmental case studies of which 80 case studies were carried out with CVM, 10 case studies with HPM, and 27 case studies with TCM. Although, the environmental case studies in our sample were published between 1987 and 2008, the majority of the studies were published from 1996 onward.

Environmental case studies classified to spatial scales

Table 2 shows the number of environmental case studies in our sample classified to spatial scale. Additionally, we categorized the case studies to subject in order to provide insight into the type of case studies that has been carried out. We describe some case studies to give an impression of the studies included in the table.

Many case studies at the local scale involve applications of CVM and HPM to subjects such as amenity of view, noise, green space in a city, and local air pollution.

Table 1. Number of studies according to our selection procedure.

Valuation method	Number of hits in Web of Science	Sample size	Environmental case studies in sample
CVM ^a	2048	205	80
HPM	131	33	10
TCM	202	51	27
Total	2381	289	117

^aThe keyword “contingent valuation” also retrieved literature regarding variants of CVM, such as contingent ranking and choice analysis/modeling/experiments.

Table 2. Environmental case studies in our sample classified to spatial scales.

Spatial scale	Valued item	Number of studies		
		CVM	HPM	TCM
Local	Amenity of view	5		
	Noise	1	3	
	Green space in city/garbage dump	11	6	
	Air quality/air pollution in city	6	1	
Landscape/watershed	Drinking water	5		
	Species	5		3
	Natural area (small to medium)	18		6
	Rivers/lakes/lagoons	15		13
	Seashore	2		
Regional	Natural area (large)	7		5
	Risk of tsunamis	1		
Global	UV light	1		
	Climate change	3		
Total		80	10	27

For instance, a CVM study examined the willingness-to-pay (WTP) for atmospheric visibility at a vista from a wilderness site and from an urban park site in Oregon (USA) on the basis of pictures with different haze levels (Crocker and Shogren 1991). Another CVM survey was undertaken in Valencia (Spain) to estimate the nonmarket benefits derived from the provision of a new urban park at the location of an old train station taking into account the proximity to the future park (Salazar and Menendez 2007). A hedonic pricing study examined the amenity value of urban forests associated with housing in Joensuu (Finland) (Tyrväinen 1997). A CVM study was conducted to obtain the WTP for the reduction in mortality risk associated with air pollution from transport in Santiago (Chile) (Ortuzar et al. 2000).

At the landscape/watershed scale, many case studies involve applications of CVM and TCM to estimate the value of natural areas, rivers, or lakes. A CVM study was conducted into the nonusers' values for preserving the wetland Norfolk Broads (UK) from the threat of saline flooding (Bateman and Langford 1997). A TCM study estimated the recreational benefits of rivers in the Colorado Rocky Mountains (Sanders et al. 1991). The benefits of recreational snapper angling in Port Phillip Bay (Australia) were estimated with a travel cost demand model (Li 1999).

At the regional scale, most case studies focused on large natural areas. With CVM, a value was placed on the endemic fynbos vegetation in South Africa by students from a range of socioeconomic backgrounds (LeMaitre et al. 1997). Another study examined domestic and international travel to the Great Barrier Reef in order to estimate the benefits the reef provides to the 2 million visitors each year (Carr and Mendelsohn 2003).

A small number of CVM studies are related to the global scale. The case studies related to climate change mitigation include two studies that focus on the WTP for electricity generated with renewables (Rose et al. 2002; Menges et al. 2005) and one study that actually focuses on the WTP for climate change mitigation (Cameron 2005). In the study of Cameron (2005), WTP of survey respondents to prevent climate change was elicited by using a referendum-type stated preference question. The demand for climate change mitigation was

modeled as a derived demand for the control of future annual average temperatures in the respondent's region.

From Table 2, we can observe that valuation methods have been applied to various subjects at different spatial scales. The HPM has exclusively been applied to value environmental quality at the local scale, whereas the TCM has most often been applied to estimate the value of environmental quality at the landscape and watershed scales. To a certain extent, the scale of the valued item is inherent to the applied method. With HPM, the value of environmental quality is revealed from local housing prices. With TCM, the value of environmental quality is revealed from trips to (recreational) sites (the physical dimension of a recreational site is often larger than what we classified as the local scale). In contrast to HPM and TCM, the CVM has been applied to value the environmental quality at various spatial scales, ranging from the local to the global scale. However, only 15% of all CVM case studies in our sample are related to the regional and global scales.

Spatial scales and publication year

Figure 1 shows the cumulative number of environmental case studies at different spatial scales as a function of the year of publication. The figure shows a striking pattern. The early case studies were primarily related to recreational activities at the landscape and watershed scales. From 1991 onward, case studies have also been applied to changes in the local environment. From 1997 onward, case studies have also been conducted to estimate the value of natural areas with a size between 10,000 and 1,000,000 km² (regional scale). Since 2002, few studies have been published that value environmental changes at the global scale. So, this graph indicates that there is an increasing attention to the valuation of environmental issues at higher spatial scales in recent years.

Discussion

The purpose of this article was to review the spatial scales of environmental goods and services that have been valued with conventional valuation methods in the scientific literature. The results show that the majority of the case studies are related

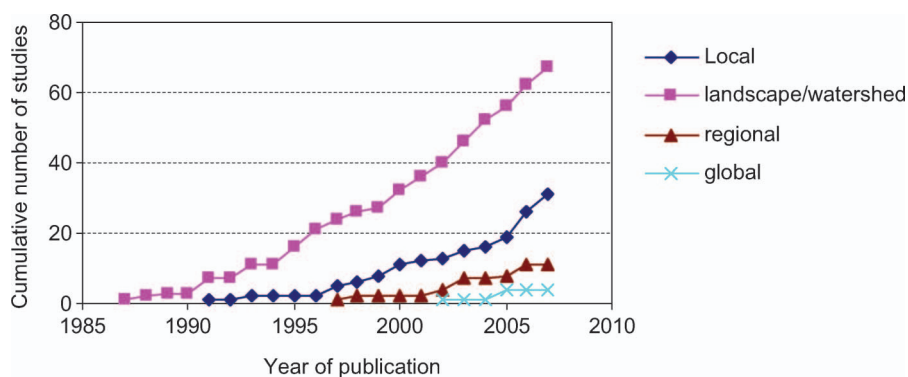


Figure 1. Cumulative number of case studies applied to environmental changes at certain spatial scales as a function of the year of publication.

to the local and landscape scales. However, the number of environmental case studies on higher spatial scales has been increasing in recent years, which could be a reflection of an increased awareness of environmental impacts at high spatial scales. A few valuation studies on climate change mitigation have been conducted in addition to the studies in our review sample (see, e.g. Layton and Brown 2000; Brouwer et al. 2008; Lee and Cameron 2008). Thus, valuation methods have recently been applied to higher spatial scales than ever before. This development calls for a reconsideration of scaling issues in environmental valuation practices, as a change in scale may have consequences for the suitability of the applied valuation methods.

Several aspects may influence the applicability of conventional valuation methods at high spatial scales. First, environmental public goods are different from private commodities in the sense that they are collectively consumed and indivisible. At low spatial scales, the differences between environmental public goods and private commodities are rather small. For example, all individuals in a neighborhood may enjoy the scenic beauty and the fresh air of an urban park. The number of people in a neighborhood is relatively small. At higher spatial scales, however, the analogy between private goods and environmental public goods is more and more blurred, as the number of individuals who benefit from the environmental public good increases. In the case of a river, all individuals who live within travelling distance of the river may visit it for recreation. Large natural areas such as the Grand Canyon or the Great Barrier Reef may attract visitors from various countries for sightseeing and recreation. Climate change may even have an impact on many people around the globe. These examples illustrate that there are limits to the analogies we can draw between the economic values of nonmarket environmental goods and those associated with private goods (Bockstael et al. 2000).

Second, respondents of contingent valuation surveys may be less acquainted with changes in environmental public goods at high spatial scales. Individuals are genuinely able to value their local environment, for example, a park or a recreational site. However, it is much more difficult for an individual to imagine and value a change in the environmental quality at a higher spatial scale, for example, changes in the global biodiversity or climate.

Third, uncertainties in environmental changes at high spatial scales may influence the valuation process, as the environmental change itself is not well-defined yet.

Fourth, in the case of climate change, the valuation may be further complicated by the spatial heterogeneity of the impacts. The impacts of climate change will differ from one geographical region to the other. A rise in the sea level may affect regions near the seaside, although it does not affect other regions. A changing climate may lead to desertification in one region, although it may have no impact or even small beneficial impacts on crop yields in another region (Intergovernmental Panel on Climate Change 2007). These site-specific impacts may lead to multiple values for climate change mitigation. Multiple values complicate decision making and hence diminish the advantages of monetary valuation.

Although, the design of a valuation study can be adjusted in order to diminish some of the difficulties related to the valuation of environmental changes at high spatial scales, it is yet unclear at what range of spatial scales valuation methods can be applied to yield valid results. Nevertheless, the results of our review study suggest that there is an increasing number of valuation studies on high spatial scales. By means of this article, we ask for attention to scaling issues in valuation studies.

Conclusions

Our survey of the valuation literature shows that the CVM, HPM, and TCM have been mainly applied to estimate the value of environmental quality at the local and landscape/watershed scales. However, our findings show that there has been an increasing attention for the valuation of environmental changes at higher spatial scales in recent years. This could be a reflection of an increased awareness of environmental impacts at high spatial scales. As a change in scale may have consequences for the applicability of conventional valuation methods, it is necessary to recognize, investigate, and discuss the effects of higher spatial scales on environmental valuation practices. This article may raise the awareness of scaling issues in valuation studies.

Notes

1. Web of Science is published by Thomson Reuters at <http://apps.isiknowledge.com>.
2. KeyWords Plus are words or phrases that frequently appear in the titles of an article's references, but do not appear in the title of the article itself. KeyWords Plus may be present for articles that have no author keywords and may include important terms not listed among the author keywords (retrieved from www.scientific.thomsonreuters.com on 15 December 2008).

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